

PUBLIC TRANSPORT TRIP GENERATION PARAMETERS FOR SOUTH AFRICA

P Onderwater

SMEC South Africa, 2 The Crescent, Westway office park, Westville 3629, Durban
Tel: 031 277 6600; Email: pieter.onderwater@smec.com

ABSTRACT

The South African Trip Generation Manuals are widely used in transportation planning, but contain no trip generation parameters for public transport (PT), although such analyses are often required in public transport plans. To close this knowledge gap, this paper has investigated the National Household Travel Survey 2013 and 4 municipal surveys to determine public transport trip generation parameters per average person for a workday.

On average a person makes 0.50 PT trips per workday: almost 0.20 for education, 0.20 for work, and some 0.10 for other purposes; a differentiation is given for different geographical areas and income levels.

The trip generation parameters for different activities are also investigated. On average a worker makes 0.75 PT trips per workday, 0.5 per scholar and 1.0 per post-matric student; again there is some differentiation per geographical area and income level.

These results will be further investigated by the author in his PhD study, and would form the basis for a future South African Public Transport Planning Manual.

1 INTRODUCTION

1.1 Trip generation parameters for PT are not available

In most transport studies, South African transportation planners make use of the Department of Transport (NDOT) *Manual for Traffic Impact Studies*, and the Committee of Transport Officials (COTO) *South African Traffic Impact and Site Traffic Assessment Manual*. These manuals, however, do not explicitly define the calculation method for trips generated by Public Transport (PT) as a mode of travel, even though this assessment is required in many PT plans.

This paper's objective is to close this knowledge gap and determine PT trip generation parameters for an average workday, for the South African situation. These parameters could for example be used to determine the PT requirements for a new development, or the Level of Service (LoS) for PT in an existing development.

1.2 Scope of this paper and methodology

This paper describes the determination of the South African PT trip generation parameters for an average workday. As PT (as part of all transportation) is derived from economic and social activities, the way to determine PT use is an investigation into activity patterns and the modal split per trip. The analyses in this paper are based upon information from the National Household Travel Survey (NHTS 2013), complemented by the Household Surveys of 4 of the biggest metropolitan Municipalities.

No distinction is made between different modes of PT: train, bus or minibus-taxi. These modes are all considered 'Public Transport', and the split between these modes is mainly depending on availability of the specific mode: e.g. there is no passenger rail transport in rural areas.

Activity trips have an origin and a destination trip-end. More than 95% of one of both trip-ends is 'home'. Analyses are done for home-based trips in residential areas (section 3) and activity-based trips in other areas (section 4).

2 ANALYSING AVAILABLE DATA

To determine the trip generation parameters, statistical information is required for residential areas (population) and activity areas (number of workers and visitors), as well as for activity patterns (trip purpose) and travel patterns (number of trips, modal split).

2.1 Information on residential and activity areas

In the National Census 2011, all kind of attributes about the population are available, very accurately and on a detailed scale. For this study the most important ones used are: employment, attending education, geographical area type, household income level, etc.

On the activity side of trips, little information is available on numbers and locations of jobs and other activities in a specific area. Although the Census gives an accurate overview on the employment of the population as well as on school attendance, these are the attributes of population, hence of residential areas, and not of activity areas. The number of workers and visitors in an activity area can therefore only be derived from the land-use of an area, in hectare or m² GLA.

2.2 Information on activity and travel patterns

Information on activity and travel patterns is captured in Household Travel Surveys (HTS), like the National Household Travel Survey (NHTS 2013), as well as Municipal Household Travel Surveys available for some of the larger Municipalities. In this paper mostly data from the NHTS is used (tabular references in this paper refer to those in the NHTS 2013 report), complemented by the latest reports on four Municipal HTS: Johannesburg (2013), Tshwane (2013), City of Cape Town (2013), and eThekweni (2007/2008).

Unfortunately these HTS are not always aligned and comparable, as questions – and therefore captured data – differ per survey. Also within a HTS these questions differ per type of activity. This could be a source of misinterpretation.

As an example: it makes a difference whether is asked if somebody in the household has made a trip (“no / yes”), or the number of trips made per person (“0 / 1 / 2 / 3 / etc.”). Other examples are given further on in the text.

2.3 Information on PT use

In some cases additional PT Census data is available, e.g. for Rail transport (PRASA). Also in Current Public Transport Records (CPTR) PT data is available, but not always accurate and gaps in information occur.

Some reliable data sets can be used to calibrate the analyses from the HTS. In addition, specific PT counts could be used. This however has not been researched for this paper.

3 HOME-BASED TRIPS

The first analyses are done for PT trips related to home-based trips: trips made as resident, where home is either the origin or destination; in both cases this trip-end will be called Origin.

3.1 Information on population and households

According to the NHST 2013 the SA population is 52.7 million, a growth of almost 1m since the Census 2011 (51.8m), which equals an annual growth rate of 1%.

The HTS does not state the total number of trips made per person or per household, but the trips are split in different activities / trip purposes: education, work, business, and ‘other’ like shopping, visit facilities, social and family trips. The trips are calculated for ‘an average person’, consisting of 34% following education and 27% working. It should be noted that these percentages differ slightly per geographical area and income level.

On an average workday 74% of the population makes a trip (table 3.3). This means that 26% stays at home that day. Reasons were given as: no need to make a trip, too old / young to make a trip, or financial reasons. The fact that these people make no trips does influence the calculated average trip generation.

The questionnaire was set up to investigate education and work trips made in the last 7 days. As these trips are generally made on a daily basis, it gives a good overview of such trips on an average workday. Other trip purposes are made less frequent and the questionnaire was adjusted to include as much information as possible.

The PT trip generation is determined by the percentage of the population traveling per trip purpose, the number of trips per average working day, and the modal split for PT. As an average PT trip generation parameter is not really suitable for planning purposes, this is further subdivided for geographical area type and income level (to what extend people can afford an activity).

Geographical differences

The NHTS 2013 distinguishes 3 types of geographical areas (see NHTS 2013, Glossary):

- Metro areas are specified as the 8 major metropolitan municipalities, and represent roughly 20,5 million of SA's population in just over 6m households, with an average household size of 3.3 (Census 2011).
- Urban areas are based on the Census 2001 classification of urban formal and informal settlements on residential land (excluding metro areas) and comprise of some 14m population in 4m households (average 3.6).
- Rural areas are based on the Census 2001 classification of farming dwellings on traditional land, and comprise of some 18m population in 4.5m households (average 4.0).

Next to the NHTS 2013, several Municipal HTS are analysed: Johannesburg, Tshwane, Cape Town and eThekweni. These are the largest of the metropolitan areas, and it could be argued that the results would be in the higher brackets for metro areas, whereas the smaller metropolitan municipalities would tend more to bigger urban areas.

It should also be noted that some of the metropolitan municipalities would still have some (semi-) rural areas (e.g. eThekweni). The presented parameters are therefore still an average.

Income differences

The income brackets in the NHTS 2013 are split in quintiles, equal groups of 20% of all households, without specifying the income levels. In this paper no/low income is determined as the lower 60% (quintile 1, 2 and 3) of the household incomes, roughly below R2000 expendable income per month. Medium income relates to 20% households in quintile 4, roughly between R2000 and R5000; where the 20% high income group have above R5000 expendable income (derived from table 9.3).

The income levels from the Municipal HTS are difficult to compare, as sometime quartiles (groups of 25%) are used, the brackets differ, or the survey is of much older date with different income values.

3.2 Education trips from/to home

The number of people following some form of education varies throughout the NHTS 2013 report: 16.4m (table 4.1), 18.4m (individually added numbers in table 4.1), 17.7m (table 4.3), 17.8m (table 4.4), and 17.4m (table 4.5 and 4.9). The modal split per geographical area and income is based upon 12.7m (table 4.2 and 4.6), and the modal split per educational institute is based upon 15.6m (table 4.7 and 4.8). This fluctuation is due to the fact of excluding unspecified cases. Considering the above numbers, it is safe to assume approx. 17.5 to 18 million people follow education; this equals some 34% of the total population.

Of the people following education, 3.5 % are so-called distance learners (table 4.3), mostly in higher education, not traveling for education on a daily basis. The majority of learners however (95%), attends education for 5 days a week (table 4.4).

Geographical differences

In metropolitan and urban areas relatively less, and in rural areas relatively more people follow education (derived from table 4.2). This is most likely a result of household size and number of people in the school-going age category, which in rural areas is relatively higher.

The average PT modal split for education is 21% (table 4.5), where PT also includes organised scholar transport, both publicly provided (for scholars living more than 3km from school), as well as private school busses. For rural areas this is 8%points lower at 13%, while for metropolitan areas the modal split is 5%points higher at 26% (table 4.2). This is most likely the result of the quality / availability of PT, which is higher in metropolitan areas. This is in line with the metropolitan HTS, where the modal split for education varies between 25 and 35%.

It could be argued that extremely long walking trips to school should be catered for by PT and should be added to the PT (latent) market. On average some 5% of scholars walk more than 60min to go to school: in metropolitan and urban areas 3%, in rural areas 8% (figure 4.3), which is the effect of a far wider spreading of population and schools in rural areas, and sometimes lack of scholar transport.

Income differences

For low income categories, the PT modal split is 8%points lower at 13%, for medium income this is 10%points higher at 31%, and for high income 5%points higher at 26% (table 4.2). This is most likely due to the affordability of PT, where low income learners prefer to walk. If corrected for including extremely long walking trips into the latent PT market (which would be applicable to the lower income brackets mostly), the modal split is more or less equal per income category at 26% on average. Of more influence is the fact that the number of people following education is lower in the higher income brackets (derived from table 4.2), due to smaller household size.

PT trip generation for education

The PT trip generation for education is determined as follows: 34% of the population following some kind of education; the majority (>95%) does so 5 days/week; each making 2 trips/day; with 21% modal split PT (plus 5% extreme walking distance). This results in $(34\% * 2 * (21+5)\%) = 0.18$ PT-trips per person on average.

Correction for geographical area and income level leads to the trip generation parameters for education, presented in table 1. It can be concluded that the differences for geographical areas are small, whereas there are significant differences for income level.

Table 1: PT trip generation (trips per average person) for education trips from/to home

PT educ. trips per workday	No/Low income	Medium income	High income	Average
Metro area	0.20	0.15	0.10	0.18
Urban area	0.18	0.13	0.09	0.16
Rural area	0.21	0.16	0.11	0.19
Average	0.20	0.15	0.10	0.18

3.3 Work trips from/to home

The number of workers varies throughout the NHTS-2013 report: 15.2m (table 5.1 and 6.1), 14.1m (table 5.2), 13.9m (table 5.3), and 13.6m (table 5.9 and 5.10). The Census 2011 states an employment of 13.2 to 13.5m, but this might have increased a bit since then. This fluctuation is due to the fact of excluding unspecified cases and could also be the result of the definition for 'worker', as to what extend informal employment, working from home, or 'business' is captured as work. Considering the above numbers, it is safe to assume approx. 14 million people work; this equals some 27% of the total population.

The majority (91%) of working people travels to work 5 or more days per week (table 5.2).

Geographical differences

In metropolitan areas relatively more, and in rural areas relatively less people work (derived from table 5.1). This is most likely a result of employment opportunities, which are higher in metro areas.

The average PT modal split for work purpose is 39% (table 5.3). For rural areas this is 3%points lower at 36%, for urban areas 8%points lower at 31%, and in metropolitan areas this is 6%points higher at 45%. This is most likely the result of generally longer travel distances in rural areas, and the quality / availability of PT in metropolitan areas. This is in line with the metropolitan HTS, where the modal split for work varies between 43 and 51%.

Income differences

For low income categories, the PT modal split is around average, although in the lowest income brackets the number of work trips is very low as a result of unemployment. In the medium income brackets relatively more people use PT: 11%points higher at 50%. This is most likely due to the effect of the affordability of PT, where low income workers prefer to walk (42%). For high income workers the PT modal split is 14%points lower at 25%. This is most likely due to higher car availability and car use (65%) in the highest income group. Given the perception of PT, it can be argued that the very-high income groups would hardly see any PT use.

PT trip generation for working

The PT trip generation for work is determined as: 27% of the population working; the majority (>90%) does so 5 days/week (the remainder 1 to 4 days/week); each making 2 trips/day; with 39% modal split PT. This results in $(27\% * 95\% * 2 * 39\% =)$ 0.20 PT-trips per person on average.

Correction for geographical area and income level leads to the trip generation parameters for workers, presented in table 2 (rounded to 0.05). It can be concluded that there are significant differences for geographical areas (metro > urban > rural), and income level (medium > high > low). The low results for the no/low income group is mostly due to the fact that part of them are unemployed, and hence make no work trips

Table 2: PT trip generation (trips per average person) for working trips from/to home

PT work trips per workday	No/Low income	Medium income	High income	Average
Metro area	0.25	0.65	0.40	0.35
Urban area	0.15	0.40	0.25	0.20
Rural area	0.10	0.25	0.15	0.15
Average	0.15	0.40	0.25	0.20

3.4 Business trips from/to home

The next trip category mentioned in the NHTS 2013 is business trips related to working duties: visiting suppliers, customers, meetings, conferences, etc. The questionnaire for these trips was set up differently and comparison is not immediately possible.

Of the 15 million workers, 1.4m indicated they made one or more business trips per month (table 6.2): 75% made 1 to 5 trips, the remainder more, up to >20 trips/month. From this table it can be calculated some 7.5m business trips (return trips) are made, a total of 15m single business trips per month, or 0.7m trips per workday. This equals 0.013 business trip per average person.

The average PT modal split for business trips is 15% (table 6.3). It can be argued that a part of the trips made by Airplane would have included PT as first or last leg to/from the airport. But still the numbers for PT are low and add up to a total PT trip generation of less than 0.005 trips per average person, rounded to 0.00.

3.5 Other travel purposes

The remainder trip purposes are clustered as 'other'. The NHTS questionnaire for these trips was again set up completely differently and comparisons were not possible. Only the 'main' purpose of 'other' trips made in the last year, was asked, and it was not recorded how often such other trips have been made.

Of the 37 million people >15 years of age, 22.5m (60%) have indicated they have made day trips with 'other' purpose in the last year (table 7.1). Most common purpose (table 7.2) was: shopping (34%), visiting home (22%), and visiting friends or family (21%). The PT modal split for day trips is 53% (table 7.3).

Similar for overnight trips, where 13.9m people (37%) have indicated they made overnight trips in the last year (table 7.4), with visiting home (47%), friends or family (26%) as the main purposes (table 7.5). The PT modal split for overnight trips is 58% (table 7.6).

In table 9.6 another overview of typical 'other' trip purposes is given: visiting shops, medical services (incl. traditional healers), and facilities as post, welfare, police, municipal, and bank offices. Again the PT modal split is between 40 and 60%.

It could however be assumed that many of these 'other' trips would most likely be made on a regular basis: e.g. shopping trips (like groceries) would be made on a monthly or weekly basis. On the other hand, some of the other trip purposes are

typically weekend trips (e.g. visiting home), and not always made on an average workday.

As it is unknown how many 'other' trips are made, it can be concluded that the NHTS 2013 cannot be used to determine PT trip generation parameters for these other trip purposes. The high PT modal split however, does give an indication of the importance of PT for these other trip purposes.

Via information from the metropolitan HTS a different approach is sought to determine these 'other' trips. In the metropolitan HTS it is indicated that of all PT trips on an average workday, some 35-45% is for education purpose and 40-45% for work (in peak hours these percentages are higher). This indicates that approx. 20% of all trips are made for other purposes. It could be assumed that this would be relatively the same for other geographical areas and all income levels.

Therefore the trip generation parameter for education plus work, has to be corrected with a factor 1.25 to include other trips. As a result on average approx. 0.10 PT-trips per person are made for other purposes on an average workday.

4 ACTIVITY RELATED TRIPS

Secondly analyses were done for activity areas, determined as the Destination-side of the trip. Different destination / activity areas include:

- Residential (domestic workers, social visitors)
- Education (workers, learners)
- Heavy and Light Industry (workers mostly)
- Office parks (workers, business visitors)
- Shops (workers, shoppers)
- Service facilities (workers, visitors)
- Health centres (workers, patients, visitors)
- Leisure (workers, visitors)

The PT trip generation is determined by the number of trips per average working day, and the modal split for PT. This is determined separately for workers and visitors. At all activity areas trips are made as worker and it can be assumed that each worker makes 2 trips per day. But per activity there will be different number of visitors (per worker).

Furthermore this is corrected for geographical area and income level, where possible.

4.1 Workers

A complicating factor is that in working areas, mostly the number of workers is not known and has to be calculated from m² GLA, or even from gross hectares of development. The conversion factors have to be based upon general urban planning principals, calibrated for the existing situation.

The majority of workers (>90%) go to work 5 or more days per week (taking into account part-time workers, sick leave, etc.), resulting in 1.9 trips/day. The average PT modal split for work trips is 39%. This equals an average generation of 0.75 PT trips per worker. The NHTS does not make any distinction between types of jobs. As

the PT modal split in metropolitan areas is slightly higher, the PT trip generation for metropolitan areas would equal 0.8, and 0.7 for jobs in urban and rural areas.

Domestic workers

Little information is available on domestic workers. The HTS of Cape Town indicates that 60% of the high income households have 1 (or sometimes 2) domestic workers, working on average 2.5 to 3 days per week. Domestic work is mostly located in high income residential areas, and therefore the PT trip generation for domestic workers is an indirect attribute for high income residents. The above information would equal to approx. 0.1 PT trips per resident (high income group only), and could also be seen as 'visitor'.

4.2 Visitors

As the number of workers is not known exactly (see above), the number of visitors is even more unknown.

Education

Apart from workers (i.e. teachers and staff), educational institutes attract many learners. Therefore the PT attraction for these 'visitors' has to be calculated separately.

PT modal split for pre-, primary- and high-school learners is 18.5% (table 4.7 and 4.8), plus 5.5% for extremely long walking distances. The majority of these scholars (99%) go to school every day, making 2 trips/day. This equals to an average PT trip generation of 0.5 per scholar. This could be corrected for income levels, although schools could attract scholars from different income groups. In predominantly low income areas the PT trip generation would be 0.6, in high income areas 0.3 per scholar.

For higher, post-matric education the PT modal split is 57% (table 4.7 and 4.8), whereas only some 65% of the students attend school every day, with 2 trips/day, and the remainder 35% 1 to 4 days a week (table 4.4), or distance learning. This equals to an average PT trip generation of 1.0 per student. As higher education is more spread, it would attract all income levels, so no further differentiation should be made.

Business visitors

Industrial working areas would not attract many visitors (mostly freight suppliers). Office parks would attract some more visitors and business contacts, some 0.5 business trips per worker. As seen in section 3.4, the PT modal split for business visits is low at 15% this results in an additional (rounded) 0.1 PT trip per worker.

Visitors to service facilities and shops

In table 9.6 the PT modal split is given for visiting shops, medical services, and facilities as post, welfare, police, municipal, and bank offices. The PT modal split is between 40 and 50%, corrected for the fact that some people do not use these services. This is in line with the PT modal split for workers (39%; and little higher in metro areas). It should however be noted that many of these visitors would visit multiple services and/or shops, and should not be counted double. The best way to indicate the number of visitors is to apply an average turn-over for visitors per

worker, as is done in the NDOT and COTO Manuals. As a result the PT trip generation per worker (including visitors) is approx. 1.5 – 2.0 trips per worker

5 CONCLUSION AND RECOMMENDATIONS

5.1 PT trip generation per resident

The total PT trip generation per resident is made up of trips for education (table 1, section 3.2), work trips (table 2, section 3.3), and other trip purposes (table 1 plus 2, multiplied by a factor 1.25, see section 3.5). The average PT trip generation parameter is 0.50, but this differs per geographical area and income level, see table 3 (rounded to 0.05).

Table 3: PT trip generation (trips per average person) for all trips from/to home

Total PT trips per workday	No/Low income	Medium income	High income	Average
Metro area	0.55	1.00	0.65	0.65
Urban area	0.40	0.65	0.45	0.45
Rural area	0.40	0.50	0.35	0.45
Average	0.45	0.70	0.45	0.50

The number of trips is relatively higher in metropolitan areas (due to more activity opportunities and better PT), and for medium income groups (more activities compared to low income, less car use than high income groups).

5.2 PT trip generation for activities

The derived PT trip generation parameters (PT trips per average workday) for activity areas are presented in table 4 (rounded to 0.1).

Table 4: PT trip generation (trips per average person) for trips to/from activities

Activity	Area	Income	PT trips per workday	Unit
Workers	Metro	All	0.8	Per worker
Workers	Urban, Rural	All	0.7	Per worker
Office visitors	All	All	0.1	Per worker
Domestic workers	Metro	High	0.1	Per high-inc. resident
Pre-matric	All	All	0.5	Per scholar
Pre-matric	All	Low	0.6	Per scholar
Pre-matric	All	High	0.3	Per scholar
Post-matric	All	All	1.0	Per student
Teachers/staff				(see workers)
Shops and facilities	All	All	1.5 – 2.0	Per worker (incl. visitors)

5.3 Other recommendations

It is assessed that the data from different HTS (both within one survey as well as between different surveys) are not always aligned. It is recommended to make them more comparable and come with comprehensive guidelines on future surveys and census.

6 THE WAY FORWARD

The PT trip generation parameters in this paper are based upon activity patterns and modal split for PT, resulting in PT trips for an average workday. This can be seen as a first step in developing a Public Transport Planning Manual. Next steps will be:

1. Calibration with (reliable) CPTR data and additional PT counts.
2. Further analysis of trips at different moments within the day: trips per peak period and peak hour (and off-peak), as well as an inward and outward directional split for PT trips per peak.
3. Distribution analysis with internal and external trips, using a gravity model.
4. The above would well describe an existing situation. But for planning purposes a future situation has to be taken into account. Therefore additionally analyses of the trend in PT use, as well as likely results of future transportation policies have to be determined.
5. Network design and route determination: whether rail, bus or minibus-taxi is available and used.
6. Operational analyses: the results can be converted into required number of minibus-taxi or bus trips per peak hour. Depending on the PT trip distance and round trip time, the total number of PT vehicles can be determined.

The results of this research paper, as well as the further steps, will be further investigated by the author in his PhD study. After presentations to relevant stakeholders, for verification and acceptance, this would finally be presented as a new South African Public Transport Planning Manual.

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